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A LOCATION STUDY OF CENTRAL ALASKAN EARTHQUAKES

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AIR FORCE TECHNICAL APPLICATIONS CENTER
Washington, D. C.

By

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13. ABSTRACT

A seismic location study has been conducted in a continental region, Central Alaska, to verify the general applicability of the travel-time anomaly technique.

First, using local stations and estimating event depths by observing pP, a set of earthquakes in the Central Alaska region was located with residual travel time errors attributable to reading error. The distribution of anomalies for teleseismic stations indicates that the Central Alaska region is composed of three subregions between which the anomalies vary by as much as 5 seconds for some stations. Some events on the edge of the local network may, however, be mislocated. Such an error could suggest an anomaly change where there was none.

The size of one of the subregions, Alaska Range, is about 150 km by 150 km, across which constant station anomalies are apparently valid for locating using a combined local and teleseismic net. Within this subregion, the event depths vary by about 40 km, from 85 km to 125 km; this suggests that no significant anomaly change is incurred due to depth.

Using a network comprised of both local and teleseismic stations, and applying as corrections anomalies determined from calibration events in each of the three subregions, the locations of the other events shift less than 5 km from the local network epicenters and the standard deviations reduce to acceptably low values.

A comparison of locations obtained using a local network with those using only a teleseismic network can be reliably obtained for only two events. The shifts from the local locations are 3 and 11 km with anomalies, as contrasted to 39 and 25 km without anomalies.

There is an indication of an average teleseismic bias of 13 km to the northwest over most of Central Alaska, thus suggesting a large anomaly region. Teleseismic locations obtained with a set of average anomalies agree as well with local locations as do locations using anomalies from events in each apparent anomaly sub-region.

14. KEY WORDS

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The size of one of the subregions, Alaska Range, is about 150 km by 150 km, across which constant station anomalies are apparently valid for locating using a combined local and teleseismic net. Within this subregion, the event depths vary by about 40 km, from 85 km to 125 km; this suggests that no significant anomaly change is incurred due to depth.

Using a network comprised of both local and teleseismic stations, and applying as corrections anomalies determined from calibration events in each of the three subregions, the locations of the other events shift less than 5 km from the local network epicenters and the standard deviations reduce to acceptably low values.

A comparison of locations obtained using a local network with those using only a teleseismic network can be reliably

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There is an indication of an average teleseismic bias of 13 km to the northwest over most of Central Alaska, thus suggesting a large anomaly region. Teleseismic locations obtained with a set of average anomalies agree as well with local locations as do locations using anomalies from events in each apparent anomaly sub-region.

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INTRODUCTION

Studies of travel-time anomalies and their effects on location accuracy and network stability have been conducted in several epicentral areas. For example, at the Nevada Test Site where the data set is comprised only of explosions, the technique of using travel-time anomalies as corrections can reduce location errors by an order of magnitude, from 25 km to 2.5-3.0 km; furthermore, location bias can be shown to be a function of the particular network used for locating (Chiburis, 1968; Chiburis and Ahner, 1970).

If the event data are comprised of earthquakes, location accuracy cannot be assessed in an absolute sense because the true locations of the events are not known. That a significant error is incurred when locating without travel-time anomalies in a region such as the Aleutian Islands has been demonstrated by locating LONG SHOT, an underground nuclear explosion on Amchitka Island in the Rat Islands, with a 329 station network. The resultant location error (with depth restrained) exceeds 20 km (Lambert et. al., 1970). As part of a recent study, Chiburis and Racine (1971) took several stable subsets of this network and showed that the resultant location errors of LONG SHOT were variable both in magnitude and direction, frequently exceeding 30 km (but also coincidentally as small as 1 km) and generally random in direction, although there was an apparent northerly bias. From these results, it was established that accurate locations are not necessarily achieved simply by having a well distributed network. In the same report, it was further shown that location consistency for a selected set of earthquakes across the Aleutian Islands region could be obtained if travel-time anomalies were

functionalized for each station recording all of the events; this consistency was manifested when, by using network subsets, a small cluster of locations was achieved for any event, and when each of the locations displayed acceptably small least-squares time errors.

Therefore, the technique of applying travel-time anomalies, even if the anomalies are determined from an unknown or mis-located event, is valid for improving location accuracy (although perhaps only relative accuracy) in regions such as the Nevada Test Site and the Aleutian Islands. Both of these regions are quite different geologically; the Nevada Test Site region is in a Basin and Range province, whereas the Aleutian Islands region is a typical island-arc structure. Although the type of structure in the vicinity of the source region should have no effect on the applicability of the anomaly technique, especially if only teleseismic stations are used, it is necessary that the technique be tested for events occurring in a "continental-type" structure to further verify the procedures. Therefore, one of the objectives of the present study is to obtain an event set from a continental region, such as Central Alaska, and investigate the variability of observed travel-time anomalies at both local and teleseismic stations as a function of event position within the region.

Another objective is to use events whose depths are known principally from identified depth phases (pP) and attempt to discern any anomaly instability or change as a function of depth.

A third objective is to investigate the location capability of a local network (all stations with less than 1,000 km epicentral distances), and using anomalies determined from the local network, of a combined local and teleseismic network and of a teleseismic only network.

REGION DEFINITION AND DESCRIPTION OF THE DATA

As used in this report, the Central Alaska region is defined as that area between Latitudes 62°N and 66°N and between Longitudes 146°W and 154°W. The shaded portion of Figure 1 shows tl region of interest.

The 33 events selected for analysis were of magnitude 4.5 or greater as reported by the National Ocean Survey (NOS) Preliminary Determination of Epicenters (PDE) lists for the time period 1964 through 1968. Figure 2 shows the distribution of the 33 events within the area of interest; also included on this figure are the event name, the reported depths and 7,000-foot contours in the Alaska Range. Table I gives the event parameter as reported by NOS.

The stations selected for the various networks total 148; of this number, 54 are World Wide Standard Seismic Stations (WWSS), 75 are Long Range Seismic Measurement (LRSM) stations, five are the F-ring and AO subarray center instruments from the Large Aperture Seismic Array (LASA) in Montana, five are VELA Observatories (OBSV) and nine are stations operated by the Geophysical Institute of the University of Alaska (U of A). Table II lists the stations by name, geographic location, type, distance and azimuth to Event Number 4, 21 June 1967, Fairbanks.

Seismograms recorded at the above stations were read for P-wave arrival times for as many of the events in Table I as possible. The distribution of the 1228 readings by station and event is shown in Table III; the reading accuracy by station type is estimated to be as follows: LASA and Observatory ±0.1 sec; LRSM ±0.2 sec; WWSS ±0.5 sec; U of A ±0.1 sec.

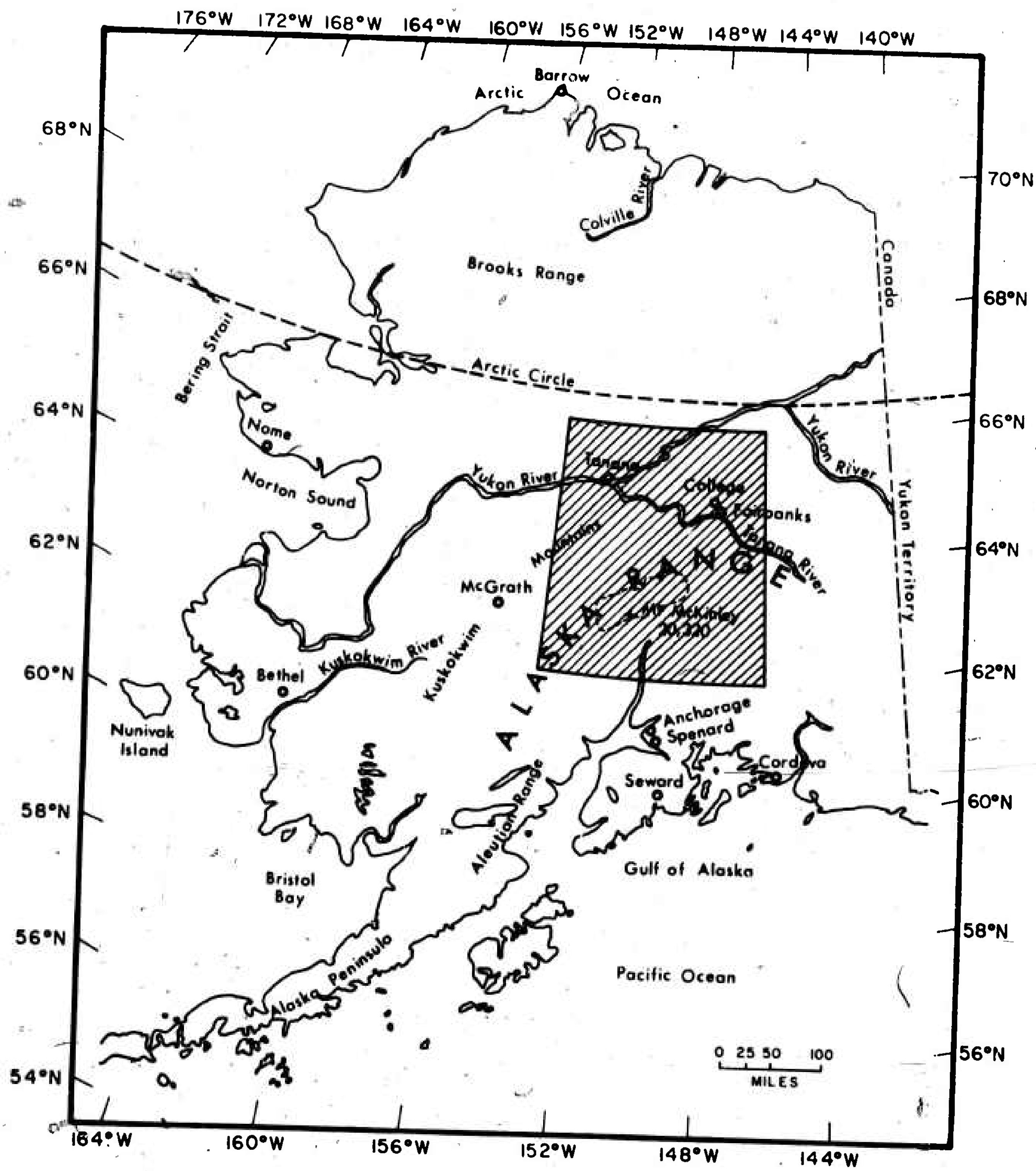

Figure 1. Geographic region of interest.

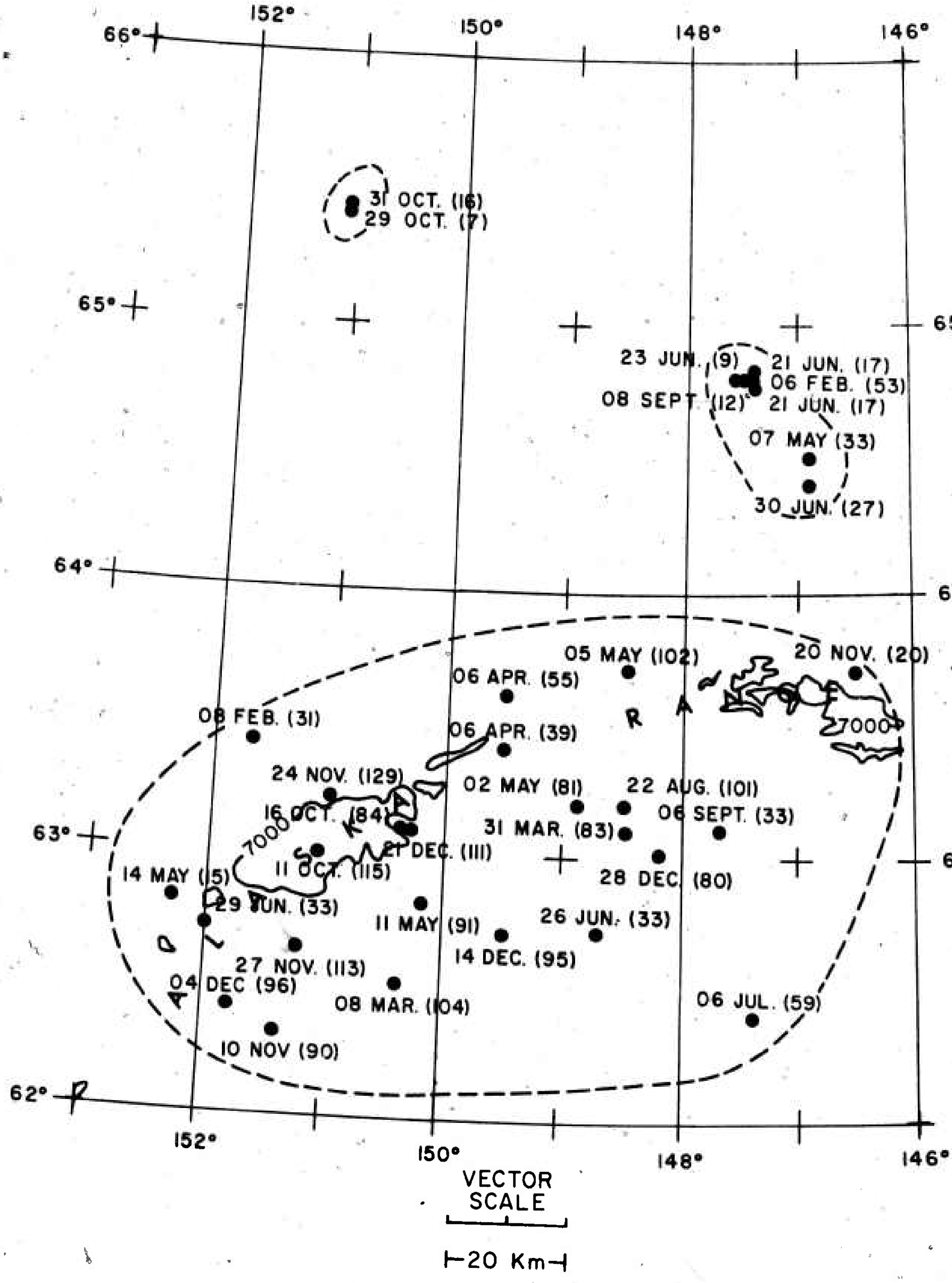

Figure 2. Distribution of epicenters.

TABLE I

Event Information Reported by the National Ocean Survey (NOS)

Event Number	Event Date	Geographic Region	Origin Time	Latitude (NOS)	Longitude (NOS)	Magnitude (NOS)	Depth (NOS)
1	29 Oct 68	Tanana	22:16:16	65.4N	150.1W	6.0	7
2	31 Oct 68	Tanana	00:25:45	65.4N	150.1W	4.5	16
3	06 Feb 67	Fairbanks	14:48:40	64.8N	147.4W	4.5	53
4	21 Jun 67	Fairbanks	18:04:49.5	64.76N	147.37W	5.4	17
5	21 Jun 67	Fairbanks	18:13:02.9	64.76N	147.37W	5.6	17
6	23 Jun 67	Fairbanks	11:54:33.5	64.82N	147.45W	4.6	9
7	08 Sep 68	Fairbanks	16:22:58	64.8N	147.6W	4.5	12
8	07 May 63	S. of Fairbanks	05:16:21	64.5N	146.9W	4.5	33
9	30 Jun 63	S. of Fairbanks	05:18:09	64.4N	146.9W	4.5	27
10	06 Apr 63	Alaska Range	11:19:23	63.4N	149.5W	5.5	39
11	06 Apr 63	Alaska Range	12:07:10	63.6N	149.5W	4.5	55
12	02 May 63	Alaska Range	23:13:13	63.2N	148.9W	6.1	81
13	22 Aug 63	Alaska Range	03:58:43	63.2N	148.5W	4.6	101
14	14 Dec 63	Alaska Range	07:51:08	62.7N	149.5W	5.1	95
15	14 May 64	Alaska Range	11:55:28	62.8N	152.3W	4.6	15
16	29 Jun 64	Alaska Range	07:21:33	62.7N	152.0W	5.6	33
17	06 Sep 64	Alaska Range	17:36:44	63.1N	147.7W	4.8	33
18	20 Nov 64	Alaska Range	21:27:40	63.7N	146.5W	4.6	80
19	27 Nov 64	Alaska Range	07:47:08	62.6N	151.5W	5.4	113
20	21 Dec 64	Alaska Range	18:32:03	63.1N	150.3W	4.8	111
21	08 Feb 65	Alaska Range	03:37:35	63.4N	151.7W	4.5	31
22	08 Mar 65	Alaska Range	12:04:21	62.5N	150.4W	4.5	104
23	26 Jun 65	Alaska Range	23:13:40	62.7N	148.7W	4.8	33
24	16 Oct 65	Alaska Range	11:45:25	63.1N	150.4W	4.6	84
25	24 Nov 65	Alaska Range	08:22:39	63.2N	151.0W	5.1	129
26	11 May 66	Alaska Range	01:26:24	62.8N	150.1W	4.7	91
27	31 Mar 67	Alaska Range	04:18:31	63.1N	148.5W	4.6	83
28	05 May 67	Alaska Range	17:06:15	63.7N	148.5W	4.9	102
29	06 Jul 67	Alaska Range	15:06:13	62.4N	147.4W	5.1	59
30	11 Oct 67	Alaska Range	07:56:36	63.0N	151.1W	4.6	115
31	10 Nov 67	Alaska Range	18:29:57	62.3N	151.4W	4.9	90
32	04 Dec 67	Alaska Range	08:19:09	62.4N	151.8W	4.9	96
33	28 Dec 68	Alaska Range	04:15:55	63.0N	148.2W	4.6	80

TABLE II

Station Information

Station Designator	Location	Latitude	Longitude	Elevation (M)	Distance (km)	Azimuth (Deg)	Type
AD-IS	Adiak Island	51 52 30.0N	176 40 45.0W	61	2211.2	243.1	LRSM
ALQ	Albuquerque, New Mexico	34 56 30.0N	106 27 30.0W	1853	4300.7	120.6	WWSS
AQU	Aquila, Italy	42 21 14.0N	13 24 11.0E	720	8013.3	14.9	WWSS
ATL	Atlanta, Georgia	33 26 00.0N	84 20 15.0W	272	5434.0	98.3	WWSS
AX2AL	Alexander City, Alabama	32 46 38.0N	86 07 48.0W	213	5412.9	100.5	LRSM
BAG	Baguio City, Philippines	16 24 39.0N	120 34 47.0E	1507	8468.5	278.9	WWSS
BEC	Bermuda-Columbia, Bermuda	32 22 46.0N	64 40 52.0W	41	6464.9	81.9	WWSS
BF-CL	Bakersfield, Califronia	35 38 53.0N	118 51 27.0W	567	3766.4	135.8	LRSM
BHP	Balboa Heights, Canal Zone	08 57 39.0N	79 33 29.0W	36	8071.4	106.5	WWSS
BIG	Big Mountain, Alaska	59 23 21.6N	155 12 58.8W	562	734.6	217.4	UofA
BLA	Blacksburg, Virgnia	37 12 40.0N	80 25 14.0W	634	5261.3	92.0	WWSS
BLR	Black Rapids, Alaska	63 30 06.0N	145 50 43.2W	792	169.3	153.2	UofA
BL-WV	Beckley, West Virginia	37 47 56.0N	81 18 36.0W	610	5164.0	92.4	LRSM
BMSO	Baker, Oregon	44 50 56.0N	117 18 20.0W	1189	2896.1	125.7	OBSV
BOG	Bogota, Columbia	04 37 23.0N	74 03 54.0W	2658	8759.3	103.2	WWSS
BOZ	Bozeman, Montana	45 36 00.0N	111 38 00.0W	1575	3054.2	117.2	WWSS
BR-PA	Berlin, Pennsylvania	39 55 27.0N	78 50 41.0W	665	5083.6	88.5	LRSM
CAR	Caracas, Venezuela	10 30 24.0N	66 55 39.0W	1035	8505.9	94.1	WWSS
CG-VA	Cumberland Gap, Virginia	36 37 35.0N	83 15 36.0W	396	5181.6	95.0	LRSM
CMC	Copper Mine, Canada	67 50 00.0N	115 05 00.0W	31	1467.9	62.6	WWSS
COL	College Outpost, Alaska	64 54 00.0N	147 47 36.0W	320	20.3	281.6	WWSS
COP	Copenhagen, Denmark	55 41 00.0N	12 26 00.0E	13	6537.5	13.2	WWSS
COR	Corvallis, Oregon	44 35 09.0N	123 18 12.0W	123	2705.0	135.0	WWSS
CP-CL	Campo, California	32 43 44.0N	116 22 16.0W	1189	4151.4	134.3	LRSM
CPSO	McMinnville, Tennessee	35 35 41.0N	85 34 13.0W	574	5170.1	98.0	OBSV
CR-NB	Crete, Nebraska	40 39 52.0N	96 51 15.0W	442	4168.4	105.3	LRSM
DAL	Dallas, Texas	32 50 46.0N	96 47 02.0W	187	4920.0	111.2	WWSS
DH-NY	Delhi, New York	42 14 39.0N	74 53 18.0W	652	5058.0	83.2	LRSM
DR-CO	Durango, Colorado	37 27 53.0N	107 47 00.0W	2225	3997.2	120.3	LRSM
DUG	Dugway, Utah	40 11 42.0N	112 48 48.0W	1477	3526.4	124.2	WWSS
EB-MT	East Braintree, Manitoba	49 37 40.0N	95 37 20.0W	312	3426.2	94.4	LRSM
EK-NV	Eureka, Nevada	39 12 32.0N	115 42 37.0W	1951	3514.0	128.9	LRSM
EN-MO	Ellsimore, Missouri	36 52 58.0N	90 35 44.0W	152	4813.0	101.9	LRSM
ESK	Eskdalemuir, Scotland	55 19 00.0N	3 12 18.0W	242	6343.6	23.5	WWSS
EU-AL	Eutaw, Alabama	32 46 45.0N	87 52 26.0W	43	5331.5	102.2	LRSM
EY-NV	Ely, Nevada	39 24 36.0N	115 18 46.0W	2012	3508.6	128.2	LRSM
FB-AK	Fairbanks, Alaska	64 57 07.0N	148 17 03.0W	716	44.3	283.2	LRSM

TABLE II (Cont'd.)

Station Information

Station Designator	Location	Latitude	Longitude	Elevation (M)	Distance (km)	Azimuth (Deg)	Type
FK-CO	Franktown, Colorado	39 35 12.0N	104 27 42.0W	1803	3930.9	114.6	LRSM
FLO	Florissant, Missouri	38 48 06.0N	90 22 12.0W	160	4642.9	327.5	WWSS
FM-UT	Fillmore, Utah	39 13 06.0N	112 12 25.0W	1890	3646.6	124.3	LRSM
FN-WV	Franklin, West Virginia	38 32 58.0N	79 30 47.0W	910	5179.3	90.2	LRSM
FO-TX	Fort Stockton, Texas	30 54 06.0N	102 41 52.0W	880	4857.8	119.0	LRSM
FR-MA	Forsyth, Montana	46 06 00.0N	106 26 25.0W	823	3233.8	110.3	LRSM
FS-AZ	Flagstaff, Arizona	35 04 09.0N	111 18 34.0W	1890	4095.7	126.3	LRSM
LF1	Miles City, Montana	47 22 15.0N	105 11 15.0W	893	3175.8	107.3	LASA
LF2	Miles City, Montana	45 54 34.0N	105 29 08.0W	907	3293.8	109.4	LASA
LF3	Miles City, Montana	45 58 22.0N	107 04 54.0W	990	3216.9	111.2	LASA
LF4	Miles City, Montana	47 24 40.0N	106 56 37.0W	860	3093.0	109.3	LASA
GDH	Godhavn, Greenland	69 15 00.0N	53 32 00.0W	23	3716.6	40.2	WWSS
GE-AZ	Globe, Arizona	33 46 32.0N	110 31 41.0W	1475	4256.1	126.3	LRSM
GEO	Georgetown, Washington, D.C.	38 54 00.0N	77 04 00.0W	43	5262.9	87.7	WWSS
GEOAL	Fairbanks, Alaska	64 51 30.0N	147 49 30.0W	400	21.4	268.5	UofA
GI-MA	Glendive, Montana	47 11 34.0N	104 13 10.0W	732	3235.6	106.4	LRSM
GOL	Golden, Colorado	39 42 01.0N	105 22 16.0W	2359	3880.9	115.5	WWSS
GSC	Goldstone, California	35 18 06.0N	116 48 17.0W	990	3871.6	133.2	WWSS
GV-TX	Grapevine, Texas	32 53 09.0N	96 59 54.0W	152	4906.6	111.4	LRSM
HD-PA	Howard, Pennsylvania	40 59 44.0N	77 35 44.0W	369	5044.2	86.6	LRSM
HN-ND	Hannah, North Dakota	48 56 53.0N	98 41 33.0W	488	3338.9	98.3	LRSM
HL-ID	Hailey, Idaho	43 38 50.0N	114 15 02.0W	1829	3132.4	122.8	LRSM
HL2ID	Hailey, Idaho	43 33 40.0N	114 25 08.0W	1829	3134.0	123.1	LRSM
HN-ME	Houlton, Maine	46 09 43.0N	67 59 09.0W	213	5025.1	74.4	LRSM
HR-AZ	Heber, Arizona	34 40 11.0N	110 45 59.0W	1875	4156.8	125.9	LRSM
HV-MA	Havre, Montana	48 25 20.0N	109 49 20.0W	884	2874.4	111.4	LRSM
HW-IS	Hawaii Island	19 58 49.0N	155 42 20.0W	705	5026.2	191.1	LRSM
HY-MA	Hysham, Montana	45 58 22.0N	107 04 54.0W	975	3216.9	111.2	LRSM
JE-LA	Jena, Louisiana	31 47 05.0N	92 00 55.0W	46	5237.5	107.0	LRSM
JP-AT	Jasper, Alberta	52 53 50.0N	118 05 25.0W	1128	2121.6	115.0	LRSM
JR-AZ	Jerome, Arizona	34 49 32.0N	111 59 25.0W	1131	94.4	127.4	LRSM
JU-TX	Juno, Texas	30 06 43.0N	101 04 38.0W	533	5004.3	117.6	LRSM
KC-MO	Kansas City, Missouri	39 21 21.0N	94 40 17.0W	274	4391.2	104.1	LRSM
KEV	Kevo, Finland	69 45 19.0N	27 00 24.0W	80	5070.5	2.7	WWSS
KIP	Kipapa, Hawaii	21 25 24.0N	158 00 54.0W	70	4891.5	194.3	WWSS
KON	Kongsberg, Norway	59 38 57.0N	9 37 55.0W	200	6071.7	14.1	WWSS
KN-UT	Kanab, Utah	37 01 22.0N	112 49 39.0W	1737	3841.4	126.8	LRSM

TABLE II (Cont'd.)
Station Information

Station Designator	Location	Latitutde	Longitude	Elevation (M)	Distance (km)	Azimuth (Deg)	Type
KIG	Kap Tobin, Greenland	70 25 00.0N	21 59 00.0W	6	4430.2	25.4	WWSS
LAO	Miles City, Montana	46 41 19.0N	106 13 20.0W	744	3190.3	109.3	LASA
LC-NM	Las Cruces, New Mexico	32 24 08.0N	106 35 58.0W	1585	4548.3	122.5	LRSM
LG-AZ	Long Valley, Arizona	34 24 28.0N	111 32 45.0W	1768	4153.5	127.1	LRSM
LON	Longmire, Washington,	46 45 00.0N	121 48 36.0W	854	2542.1	130.2	WWSS
LPS	Lapalma, El Salvador	14 17 32.0N	89 09 43.0W	1000	7105.5	113.4	WWSS
LS-NH	Lisbon, New Hampshire	44 14 18.0N	71 55 21.0W	287	5061.2	79.1	LRSM
LUB	Lubbock, Texas	33 35 00.0N	101 52 00.0W	200	4626.8	116.3	WWSS
LZ-BV	La Paz, Bolivia	16 15 31.0S	68 28 47.0W	3993	11112.3	106.9	LRSM
MAL	Malaga, Spain	36 43 39.0N	04 24 40.0W	60	8302.7	30.1	WWSS
MAN	Manila, Philippines	14 40 00.0N	121 05 00.0E	70	8618.2	277.7	WWSS
MCB	Moose Creek, Alaska	64 43 15.0N	147 13 42.0W	400	17.4	156.5	UofA
MDS	Madison, Wisconsin	43 22 20.0N	89 45 36.0W	278	4250.9	95.6	WWSS
MNN	Minneapolis, Minnesota	44 54 52.0N	93 11 24.0W	217	3950.6	97.5	WWSS
MN-NV	Mina, Nevada	38 26 10.0N	118 08 53.0W	1524	3504.5	132.8	LRSM
MO-ID	Mountain Home, Idaho	43 04 19.0N	116 15 56.0W	792	3109.5	126.2	LRSM
MV-CL	Marysville, California	39 12 47.0N	121 17 35.0W	183	3318.9	136.7	LRSM
NDI	New Delhi, India	28 41 00.0N	77 13 00.0E	230	8955.1	321.3	WWSS
NL-AZ	Nazlini, Arizona	35 54 05.0N	109 34 10.0W	1768	4080.0	123.6	LRSM
NL2AZ	Nazlini, Arizona	35 48 25.0N	109 37 43.0W	1920	4087.1	123.7	LRSM
NNA	Nana, Peru	11 59 15.2S	76 50 31.7W	575	10308.9	112.5	WWSS
NOR	Nord, Greenland	81 36 00.0N	16 41 00.0W	36	3493.3	12.4	WWSS
NP-NT	Mould Bay, Canada	76 15 08.0N	119 22 18.0W	59	1612.4	26.6	LRSM
NUR	Nurmijarvi, Finland	60 30 32.0N	24 39 05.0E	102	6093.6	4.8	WWSS
OGD	Ogdensburg, New Jersey	41 04 00.0N	74 37 00.0W	373.	5178.6	83.9	WWSS
OO-NW	Oslo, Norway	61 02 53.0N	10 53 42.0E	555	5932.8	13.0	LRSM
OXF	Oxford, Mississippi	34 30 43.0N	89 24 33.0W	101	5093.9	102.5	WWSS
PG-BC	Prince George, Brit. Columbia	53 59 50.0N	122 31 23.0W	914	1839.7	119.4	LRSM
PG2BC	Prince George, Brit. Columbia	53 59 28.0N	122 30 44.0W	747	1840.6	119.4	LRSM
PI2WY	Pinedale 2, Wyoming	42 46 02.0N	109 33 43.0W	2195	3409.2	117.7	LRSM
PJD	Pedro Dome, Alaska	65 02 03.6N	147 30 33.0W	740	20.1	341.5	UofA
PMG	Port Moresby, New Guinea	09 24 33.0S	147 09 14.0E	70	9828.4	243.9	WWSS
PTO	Porto, Portugal	41 08 19.0N	08 36 08.0W	88	7730.1	32.1	WWSS
PT-OR	Pendleton, Oregon	45 36 40.0N	118 53 02.0W	411	2761.8	127.1	LRSM
QUE	Quetta, Pakistan	30 11 18.0N	66 57 00.0E	1713	0968.1	330.4	WWSS
RAB	Rabaul, New Britain	04 11 28.6S	152 10 11.4E	184	0984.2	241.3	WWSS
RG-SD	Redig, South Dakota	45 12 59.0N	103 32 03.0W	945	3444.6	108.0	LRSM

TABLE II (Cont'd.)

Station Information

Station Designator	Location	Latitude	Longitude	Elevation (M)	Distance (km)	Azimuth (Deg)	Type
RK-ON	Red Lake, Ontario	50 50 20.0N	93 40 20.0W	366	3417.9	91.0	LRSM
RT-NM	Raton, New Mexico	36 43 46.0N	104 21 37.0W	1951	4212.1	116.8	LRSM
RY-ND	Ryder, North Dakota	48 05 50.0N	101 29 40.0W	640	3281.4	102.3	LRSM
SCM	Sheep Creek Mt., Alaska	61 50 00.0N	147 19 39.6W	1020	338.4	179.6	UofA
SCP	State College, Penna.	40 47 42.0N	77 51 54.0W	352	5049.8	87.0	WWSS
SE-MN	Sleepy Eye, Minnesota	44 24 51.0N	94 39 55.0W	244	3926.1	99.4	LRSM
SEO	Seoul, Korea	37 34 00.0N	126 58 00.0E	86	6107.7	284.5	WWSS
SG-AZ	Seligman, Arizona	35 38 27.0N	113 15 39.0W	1676	3964.4	128.4	LRSM
SHA	Spring Hill, Alabama	30 41 41.1N	88 08 23.0W	59	5520.9	103.8	WWSS
SHI	Shiraz, Iran	29 48 39.0N	52 51 34.0E	1595	9376.5	342.4	WWSS
SHL	Shillong, India	25 34 00.0N	91 53 00.0E	1600	8784.2	307.7	WWSS
SI-BC	Smithers, Brit. Columbia	54 47 18.0N	127 04 17.0W	579	1587.8	125.4	LRSM
SJ-TX	San Jose, Texas	27 36 43.0N	98 18 46.0W	114	5370.9	116.1	LRSM
SN-AZ	Sunflower, Arizona	33 51 49.0N	111 41 34.0W	884	4203.0	127.6	LRSM
SS-TX	Sanderson, Texas	30 01 17.0N	102 19 41.0W	732	4961.1	119.1	LRSM
STU	Stuttgart, Germany	48 46 15.0N	9 11 36.0E	375	7255.0	16.8	WWSS
SV2QB	Schefferville, Quebec	54 48 54.0N	66 45 31.0W	594	4331.7	65.3	LRSM
SV3QB	Schefferville, Quebec	54 48 39.0N	66 45 00.0W	579	4332.4	65.3	LRSM
SVW	Sparrevohn, Alaska	61 06 29.4N	155 37 06.0W	762	591.6	228.7	UofA
SW-MA	Sweetgrass, Montana	48 58 08.0N	111 57 46.0W	1113	2731.5	113.3	LRSM
TFSO	Payson, Arizona	34 16 03.8N	111 16 13.2W	1492	4178.1	126.8	OBSV
TR-WA	Tonasket, Washington	48 47 38.0N	119 35 16.0W	549	2429.9	124.1	LRSM
TNN	Tanana, Alaska	65 15 24.0N	151 54 42.0W	504	218.3	283.6	UofA
TOL	Toledo, Spain	39 52 53.0N	4 02 55.0W	480	7973.8	29.0	WWSS
TRN	Trinidad, West Indies	10 39 00.0N	61 24 06.0W	24	8753.9	89.1	WWSS
TUC	Tucson, Arizona	32 18 35.0N	110 45 56.0W	985	4394.9	127.5	WWSS
UBSO	Vernal, Utah	40 19 18.0N	109 34 07.0W	1600	3644.4	120.0	OBSV
VAL	Valentia, Ireland	51 56 00.0N	10 15 00.0W	14	6551.8	29.5	WWSS
VO-IO	Vinton, Iowa	42 13 30.0N	92 07 37.0W	274	4243.7	99.0	LRSM
WES	Weston, Massachusetts	42 23 04.9N	71 19 19.5W	60	5212.7	80.1	WWSS
WF-NM	Wykoff, Minnesota	43 48 05.0N	92 22 23.0W	381	4088.9	97.8	LRSM
WH2YK	White Horse, Yukon	60 41 41.0N	134 58 02.0W	853	784.7	120.6	LRSM
WI-NV	Winnemucca, Nevada	41 21 02.0N	117 27 30.0W	1524	3235.2	129.4	LRSM
WMSO	Lawton, Oklahoma	34 43 05.0N	98 35 21.0W	505	4657.8	111.9	OBSV
WN-SD	Winner, South Dakota	43 15 08.0N	100 11 46.0W	792	3775.8	106.4	LRSM
WO-AZ	Winslow, Arizona	34 52 53.0N	110 37 15.0W	1585	4141.1	125.6	LRSM
WRTAL	Fort Wainwright, Alaska	64 49 42.0N	147 34 00.0W	400	10.0	246.6	UofA

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TABLE III

Distribution of P-wave Arrival Times by Station and Event

Station Name	Number Readings	01-29 Oct 68	02-31 Oct 68	03-06 Feb 67	04-21 Jun 67	05-21 Jun 67	06-23 Jun 67	07-08 Sep 68	08-07 May 63	09-30 Jun 63	10-06 Apr 63	11-06 Apr 63	12-02 May 63	13-22 Aug 63	14-14 Dec 63	15-14 May 64	16-29 Jun 64	17-06 Sep 64	18-20 Nov 64	19-27 Nov 64	20-21 Dec 64	21-08 Feb 65	22-08 Mar 65	23-26 Jun 65	24-16 Oct 65	25-24 Nov 65	26-11 May 66	27-31 Mar 67	28-05 May 67	29-06 Jul 67	30-11 Oct 67	31-10 Nov 67	32-04 Dec 67	33-28 Dec 68
Number of Stations →		50	35	28	58	45	37	28	36	25	29	41	17	30	50	58	75	54	33	64	47	30	40	42	20	43	35	13	45	50	34	51	38	13
WRTAL	2	✓	✓																															
MCBAL	3	✓	✓																															✓
PJD	12	✓	✓	✓	✓		✓	✓																				✓	✓		✓	✓	✓	✓
COL	21	✓	✓	✓	✓		✓									✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
GEAOL	4	✓	✓				✓																											✓
FB-AK	1							✓																										
BLR	9	✓	✓		✓		✓	✓																							✓	✓	✓	✓
TNN	12	✓	✓	✓	✓		✓	✓																				✓	✓		✓	✓	✓	✓
SCM	12	✓	✓	✓	✓		✓	✓																				✓	✓		✓	✓	✓	✓
SVW	6	✓	✓					✓																							✓	✓		✓
BIG	9			✓	✓		✓																					✓	✓		✓	✓	✓	✓
WH2YK	13	✓	✓	✓	✓		✓	✓																				✓	✓	✓	✓	✓	✓	✓
CMC	17			✓					✓						✓	✓	✓	✓	✓	✓		✓	✓	✓			✓		✓	✓	✓	✓	✓	
SI-BC	2																									✓	✓							
NP-NT	25	✓	✓	✓	✓		✓	✓						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
PG-BC	10			✓	✓			✓																		✓	✓		✓	✓	✓	✓	✓	
PG2BC	1	✓																																
JP-AT	2																									✓	✓							
AD-IS	6																	✓	✓		✓		✓	✓		✓								
TK-WA	1															✓																		
LON	26	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	
COR	4	✓			✓		✓								✓																			
SW-MN	2																									✓	✓							
PT-OR	1								✓																									
HV-MA	1																									✓								
BMSO	15								✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓							
BOZ	17														✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		
LF4	9	✓	✓	✓	✓		✓																						✓		✓	✓	✓	
MO-ID	3			✓	✓	✓																												
HL-ID	7								✓	✓	✓	✓	✓	✓	✓																			
HL2ID	10																✓	✓		✓	✓	✓		✓	✓						✓	✓	✓	
LF1	12	✓	✓	✓	✓		✓	✓																			✓		✓	✓	✓	✓	✓	
LAO	13	✓	✓	✓	✓	✓	✓	✓																			✓		✓	✓	✓	✓	✓	
LF3	12	✓	✓	✓	✓		✓	✓																			✓		✓	✓	✓	✓	✓	
HY-MA	1																				✓													
FR-MA	1																✓																	
WI-NV	1								✓																									

TABLE III (Cont'd.)

Distribution of P-wave Arrival Times by Station and Event

Station Name	Number Readings	01-29 Oct 68	02-31 Oct 68	03-06 Feb 67	04-21 Jun 67	05-21 Jun 67	06-23 Jun 67	07-08 Sep 68	08-07 May 63	09-30 Jun 63	10-06 Apr 63	11-06 Apr 63	12-02 May 63	13-22 Aug 63	14-14 Dec 63	15-14 May 64	16-29 Jun 64	17-06 Sep 64	18-20 Nov 64	19-27 Nov 64	20-21 Dec 64	21-08 Feb 65	22-08 Mar 65	23-26 Jun 65	24-16 Oct 65	25-24 Nov 65	26-11 May 66	27-31 Mar 67	28-05 May 67	29-06 Jul 67	30-11 Oct 67	31-10 Nov 67	32-04 Dec 67	33-28 Dec 68
Number of Stations →		50	35	28	58	45	37	28	36	25	29	41	17	30	50	58	75	54	33	64	47	30	40	42	20	43	35	13	45	50	34	51	38	13
TFSO	29	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
SN-AZ	6															✓	✓				✓	✓	✓	✓										
RT-NM	7															✓	✓	✓	✓	✓	✓		✓											
VO-IO	3																	✓		✓			✓											
MDS	8									✓				✓		✓	✓	✓		✓			✓		✓									
GE-AZ	8															✓		✓	✓	✓	✓	✓	✓	✓										
ALQ	29	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	
SV2QB	4																			✓	✓	✓		✓										
SV3QB	9				✓	✓	✓	✓																		✓			✓	✓		✓	✓	
KC-MO	2																									✓	✓							
TUC	30	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	
KTG	11	✓	✓		✓	✓	✓							✓	✓	✓	✓												✓			✓		
LC-MN	19	✓						✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓								✓	✓	✓
LUB	21				✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓		✓	✓		✓			✓	✓	✓		✓	
FLO	23	✓		✓	✓		✓			✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓		
WMSO	28	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	
EN-MO	1																									✓								
FO-TX	4																✓			✓	✓		✓											
KIP	6	✓				✓									✓		✓												✓	✓				
GV-TX	3																✓			✓						✓								
DAL	4											✓			✓					✓						✓								
SS-TX	2											✓	✓																					
JU-TX	2															✓	✓																	
LS-NH	4															✓	✓	✓		✓														
HN-ME	19	✓				✓			✓	✓		✓			✓	✓	✓	✓		✓	✓		✓	✓		✓			✓	✓		✓	✓	
HW-IS	1																✓																	
HD-PA	2																			✓	✓													
SCP	22	✓	✓					✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓		✓	✓	✓			✓		✓	✓	✓	
DH-NY	6														✓		✓	✓		✓	✓			✓										
KEV	11	✓			✓	✓	✓				✓		✓		✓		✓	✓		✓										✓				
BR-PA	10								✓							✓	✓	✓	✓	✓	✓	✓	✓	✓										
OXF	18	✓	✓	✓	✓	✓	✓								✓	✓	✓			✓	✓		✓				✓		✓	✓	✓	✓	✓	
BL-WV	14								✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓										
CPSO	18								✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓							
CGD	8	✓					✓								✓	✓								✓		✓				✓		✓		
FN-WV	4															✓	✓							✓	✓									
CG-VA	1																							✓										

TABLE III (Cont'd.)

Distribution of P-wave Arrival Times by Station and Event

Station Name	Number Readings	01-29 Oct 68	02-31 Oct 68	03-06 Feb 67	04-21 Jun 67	05-21 Jun 67	06-23 Jun 67	07-08 Sep 68	08-07 May 63	09-30 Jun 63	10-06 Apr 63	11-06 Apr 63	12-02 May 63	13-22 Aug 63	14-14 Dec 63	15-14 May 64	16-29 Jun 64	17-06 Sep 64	18-20 Nov 64	19-27 Nov 64	20-21 Dec 64	21-08 Feb 65	22-08 Mar 65	23-26 Jun 65	24-16 Oct 65	25-24 Nov 65	26-11 May 66	27-31 Mar 67	28-05 May 67	29-06 Jul 67	30-11 Oct 67	31-10 Nov 67	32-04 Dec 67	33-28 Dec 68
Number of Stations→		50	35	28	58	45	37	28	36	25	29	41	17	30	50	58	75	54	33	64	47	30	40	42	20	43	35	13	45	50	34	51	38	13
WES	7	✓																✓						✓			✓		✓	✓		✓		
JE-LA	3															✓	✓	✓																
BLA	23	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓		✓		✓		✓			✓	✓	✓			
GEO	14	✓			✓	✓	✓			✓		✓			✓		✓	✓		✓				✓		✓						✓	✓	
EU-AL	2																✓	✓																
SJ-TX	1								✓																									
AX2AL	1																										✓							
ATL	23	✓	✓			✓	✓	✓						✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	
SHA	4				✓	✓						✓					✓																	
OO-NW	2																✓			✓														
KON	5	✓										✓					✓				✓									✓				
NUR	15	✓			✓	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓		✓									✓			✓		
SEO	5	✓			✓	✓											✓				✓													
ESK	8	✓			✓	✓	✓										✓	✓											✓	✓				
BEC	6	✓			✓	✓									✓	✓	✓																	
COP	2											✓					✓																	
VAL	5	✓									✓	✓			✓															✓				
LPS	16				✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓		✓				✓			✓			✓				
STU	5	✓			✓	✓						✓																		✓				
PTO	8	✓			✓	✓						✓			✓					✓										✓		✓		
TOL	15				✓	✓			✓	✓	✓	✓			✓	✓	✓	✓		✓	✓								✓	✓		✓		
AQU	7	✓	✓		✓	✓												✓		✓										✓				
BHP	6	✓			✓	✓											✓			✓										✓				
MAL	5	✓			✓	✓								✓																✓				
BAG	9	✓			✓	✓		✓				✓			✓					✓									✓	✓				
CAR	7	✓			✓	✓									✓		✓			✓												✓		
MAN	1											✓																						
TRN	4	✓				✓						✓			✓																			
BOG	7	✓				✓								✓	✓		✓			✓										✓				
SHL	17	✓			✓				✓	✓			✓		✓	✓		✓	✓	✓	✓				✓	✓	✓		✓		✓	✓		
NDI	14				✓		✓		✓		✓			✓	✓	✓	✓			✓	✓					✓			✓	✓		✓		
QUE	17	✓	✓		✓					✓	✓	✓		✓	✓	✓			✓	✓	✓					✓			✓	✓		✓	✓	
RAB	2				✓	✓																												
SHI	12	✓			✓	✓									✓	✓		✓	✓	✓	✓					✓				✓		✓		
PMG	5	✓			✓	✓									✓				✓															
NNA	6					✓					✓	✓				✓	✓													✓				
LZ-BV	1																✓																	

TABLE III (Cont'd.)

Distribution of P-wave Arrival Times by Station and Event

Station Name	Number Readings	01-29 Oct 68	02-31 Oct 68	03-06 Feb 67	04-21 Jun 67	05-21 Jun 67	06-23 Jun 67	07-08 Sep 68	08-07 May 63	09-30 Jun 63	10-06 Apr 63	11-06 Apr 63	12-02 May 63	13-22 Aug 63	14-14 Dec 63	15-14 May 64	16-29 Jun 64	17-06 Sep 64	18-20 Nov 64	19-27 Nov 64	20-21 Dec 64	21-08 Feb 65	22-08 Mar 65	23-26 Jun 65	24-16 Oct 65	25-24 Nov 65	26-11 May 66	27-31 Mar 67	28-05 May 67	29-06 Jul 67	30-11 Oct 67	31-10 Nov 67	32-04 Dec 67	33-28 Dec 68
Number of Stations→		50	35	28	58	45	37	28	36	25	29	41	17	30	50	58	75	54	33	64	47	30	40	42	20	43	35	13	45	50	34	51	38	13
GI-MA	2															✓	✓																	
RY-ND	4																✓	✓		✓			✓											
LF2	10	✓	✓		✓		✓	✓																			✓			✓	✓	✓	✓	
MU-CL	1								✓																									
HH-ND	2															✓	✓																	
PI2WY	1																						✓											
RK-ON	24	✓	✓	✓	✓	✓		✓							✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
EB-MT	2															✓	✓																	
RG-SD	1																									✓								
NOR	16	✓	✓		✓	✓									✓	✓	✓	✓		✓						✓	✓		✓	✓	✓	✓	✓	
MN-NV	30	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
EY-NV	1								✓																									
EK-NV	3															✓	✓	✓																
DUG	25	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓		
UBSO	33	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
FM-UT	1								✓																									
GDH	9	✓			✓	✓					✓	✓		✓			✓												✓	✓				
BF-CL	1								✓																									
WN-SD	7											✓					✓	✓									✓				✓	✓	✓	
KN-UT	31	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
GSC	26		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓		✓	✓	
GOL	26	✓	✓	✓	✓		✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	✓	✓	
SE-MN	1								✓																									
FK-CO	1																											✓						
MNN	5											✓			✓		✓	✓		✓														
SG-AZ	5															✓	✓			✓	✓		✓											
DR-CO	7								✓							✓	✓	✓	✓	✓	✓													
NL-AZ	5																✓	✓	✓	✓	✓													
NL2AZ	1																						✓											
WF-NM	1																	✓																
JR-AZ	8															✓	✓	✓		✓	✓	✓	✓	✓										
FS-AZ	1								✓																									
WO-AZ	7															✓	✓			✓	✓	✓	✓	✓										
CP-CL	6								✓	✓	✓	✓		✓	✓																			
LG-AZ	7															✓	✓			✓	✓	✓	✓	✓										
HR-AZ	7																	✓	✓	✓	✓	✓	✓	✓										
CR-NB	1																									✓								

The principal reasons for the different estimated accuracies are the differences in seismogram recording speed; however, overall quality of the seismic traces (thickness, focus, etc.) is also a factor.

INITIAL TRAVEL-TIME ANOMALIES

Using the NOS reported hypocenter parameters listed in Table I, travel-time anomalies were calculated for all stations and events. Previous experience in other regions has shown that the anomalies vary significantly with location; therefore, the reported locations were used to separate the events into three subregions so as to note any anomaly patterns across Central Alaska. These three subregions are referred to in this report as Tanana (which includes 2 events), Fairbanks (7 events), and Alaska Range (24 events); the dashed-line areas in Figure 2 show the space relationships of the three subregions.

Travel-time anomalies are computed in the usual manner; the anomaly at station i relative to station j is

$$A_{i/j} = T_i - T_j - H_i(\Delta,z) + H_j(\Delta,z)$$

where T is station arrival time and H is predicted travel-time for an event at distance Δ and depth z based on the travel-time table of Herrin (1968). All anomalies in this report are made relative to station UBSO as a matter of convenience. The anomalies by event for several stations are given in Table IV; these stations were selected to illustrate the generally poor consistency observed. With anomaly differences within a subregion larger than 4 seconds at teleseismic stations and 6 seconds at local stations, seismogram reading errors can immediately be eliminated as the sole source of the discrepancies. Previous experience has shown that the chief causes of anomaly inconsistency are epicenter mislocations and depth errors (Chiburis and Dean, 1965; Chiburis, 1968; Chiburis and Ahner, 1970;

TABLE IV

Travel-Time Anomalies at Selected Stations As Computed from NOS Hypocenters Listed in Table I

No.	Event Date	COL	NP-NT	SCP	TNN
1	29 Oct 68	-2.44	-5.60	-3.04	-0.17
2	31 Oct 68	-2.83	-6.18	-2.41	-1.51
Average		-2.64	-5.89	-2.73	-0.84
Standard Deviation		0.28	0.41	0.45	0.95
3	06 Feb 67	-3.18	-1.34	--	+1.62
4	21 Jun 67	-5.55	-2.14	--	-4.56
5	21 Jun 67	--	--	--	--
6	23 Jun 67	-2.70	-3.09	--	-3.23
7	08 Sep 68	--	-2.76	--	-2.20
8	07 May 63	--	--	--	--
9	30 Jun 63	--	--	-0.63	--
Average		-3.81	-2.33	-0.63	-2.09
Standard Deviation		1.53	0.77	--	2.66
10	06 Apr 63	--	--	-1.28	--
11	06 Apr 63	--	--	-1.05	--
12	02 May 63	--	--	-0.26	--
13	22 Aug 63	--	+1.90	-0.55	--
14	14 Dec 63	--	-1.50	-3.44	--
15	14 May 64	-0.17	+2.17	-0.34	--
16	29 Jun 64	--	-1.44	-1.25	--
17	06 Sep 64	--	-1.29	--	--
18	20 Nov 64	-2.27	+0.51	-0.25	--
19	27 Nov 64	-0.76	-1.17	-0.58	--
20	21 Dec 64	+0.14	+1.31	--	--
21	08 Feb 65	-2.75	-0.99	-4.64	--
22	08 Mar 65	-1.68	--	--	--
23	26 Jun 65	+1.96	+2.21	-1.42	--
24	16 Oct 65	-1.75	-0.17	-1.69	--
25	24 Nov 65	-0.91	+0.68	-1.37	--
26	11 May 66	-1.41	+0.71	-1.25	--
27	31 Mar 67	--	-1.51	--	-1.05
28	05 May 67	-1.78	-1.71	-1.45	-0.70
29	06 Jul 67	+0.41	--	--	--
30	11 Oct 67	-1.11	--	-1.05	-0.46
31	10 Nov 67	-1.35	-1.13	-1.13	-0.77
32	04 Dec 67	-0.22	-0.22	-0.71	+0.24
33	28 Dec 68	-3.41	-2.60		-1.90
Average		-1.07	-0.24	-1.32	-0.77
Standard Deviation		1.31	1.47	1.10	0.70
Overall Average		-1.61	-1.06	-1.42	-1.22
Standard Deviation		1.61	2.13	1.12	1.63

Chiburis and Racine, 1971). To eliminate possible errors in the reported depths, each of the events was analyzed by aligning the P waves at all stations as a function of distance and then selecting apparent pP phases based on coherent energy across the network. The assistance which such a technique can provide is well known and was demonstrated by Chiburis and Ahner (1969). The observed (pP-P) time differences were converted to depth using the relation of Jeffreys and Shimshoni (1964). A comparison between the depths thus obtained and the NOS reported depths is shown in Table V. Of the 33 event depths, twenty disagree by less than 7 km and only seven disagree by more than 20 km of which four disagree by more than 60 km.

TABLE V

A Comparison Between NOS Reported and Depths Determined by pP Observations

Event No.	Date	NOS Depth (km)	pP Depth (km)	dz (km)
1	29 Oct 68	7	13	+6
2	31 Oct 68	16	16	0
3	06 Feb 67	53	28	-25
4	21 Jun 67	17	16	-1
5	21 Jun 67	17	13	-4
6	23 Jun 67	9	16	+7
7	08 Sep 68	12	8	-4
8	07 May 63	33	13	-20
9	30 Jun 63	27	9	-18
10	06 Apr 63	39	108	+69
11	06 Apr 63	55	115	+60
12	02 May 63	81	85	+4
13	22 Aug 63	101	78	-23
14	14 Dec 63	95	108	+13
15	14 May 64	15	16	+1
16	29 Jun 64	33	21	-12
17	06 Sep 64	33	134	+101
18	20 Nov 64	80	85	+5
19	27 Nov 64	113	113	0
20	21 Dec 64	111	108	-3
21	08 Feb 65	31	15	-16
22	08 Mar 65	104	105	+1
23	26 Jun 65	33	134	+101
24	16 Oct 65	84	97	+13
25	24 Nov 65	129	134	+5
26	11 Nov 66	91	85	-6
27	31 Mar 67	83	82	-1
28	05 May 67	102	100	-2
29	06 Jul 67	59	54	-5
30	11 Oct 67	115	113	-2
31	10 Nov 67	90	93	+3
32	04 Dec 67	96	108	+12
33	28 Dec 68	80	82	+2

RELOCATIONS USING A LOCAL NETWORK

If the pP-determined depths are accepted as being correct, a local network can be used to relocate the epicenters of the 12 events satisfactorily recorded by it, restraining the depths to the accepted values and applying no anomalies as corrections. The geometry of the local network used for this purpose is shown in Figure 3.

The location-shifts from the 12 NOS reported epicenters and the standard deviations of the least-squares time fits for the local network are given in Table VI; also indicated are the stations used in making each of the locations. We used the Herrin (1968) travel time curves. A significant result in this table is the improvement achieved in the standard deviation of the time-fit location when compared with the standard deviation determined from the input location. Except for the Tanana subregion, where the improvement is negligible and where the local network control is poorest, the resultant standard deviations approach those which one would expect from reading errors alone.

Some other points relevant to Table VI: the NOS reported location of the 06 February 1967 Fairbanks event was clearly in error. The standard deviation for six local stations is nearly 4 seconds as computed from the NOS epicenter and pP depth. Since the NOS location was obtained with a depth of 53 km instead of 28 km, it is probable that the depth error was responsible for most of the mislocation. Using the local network, the solution obtained for this event with a restrained depth of 28 km is now consistant with the other events in the Fairbanks subregion. Excluding the 06 February 1967 event, the average shift of the event

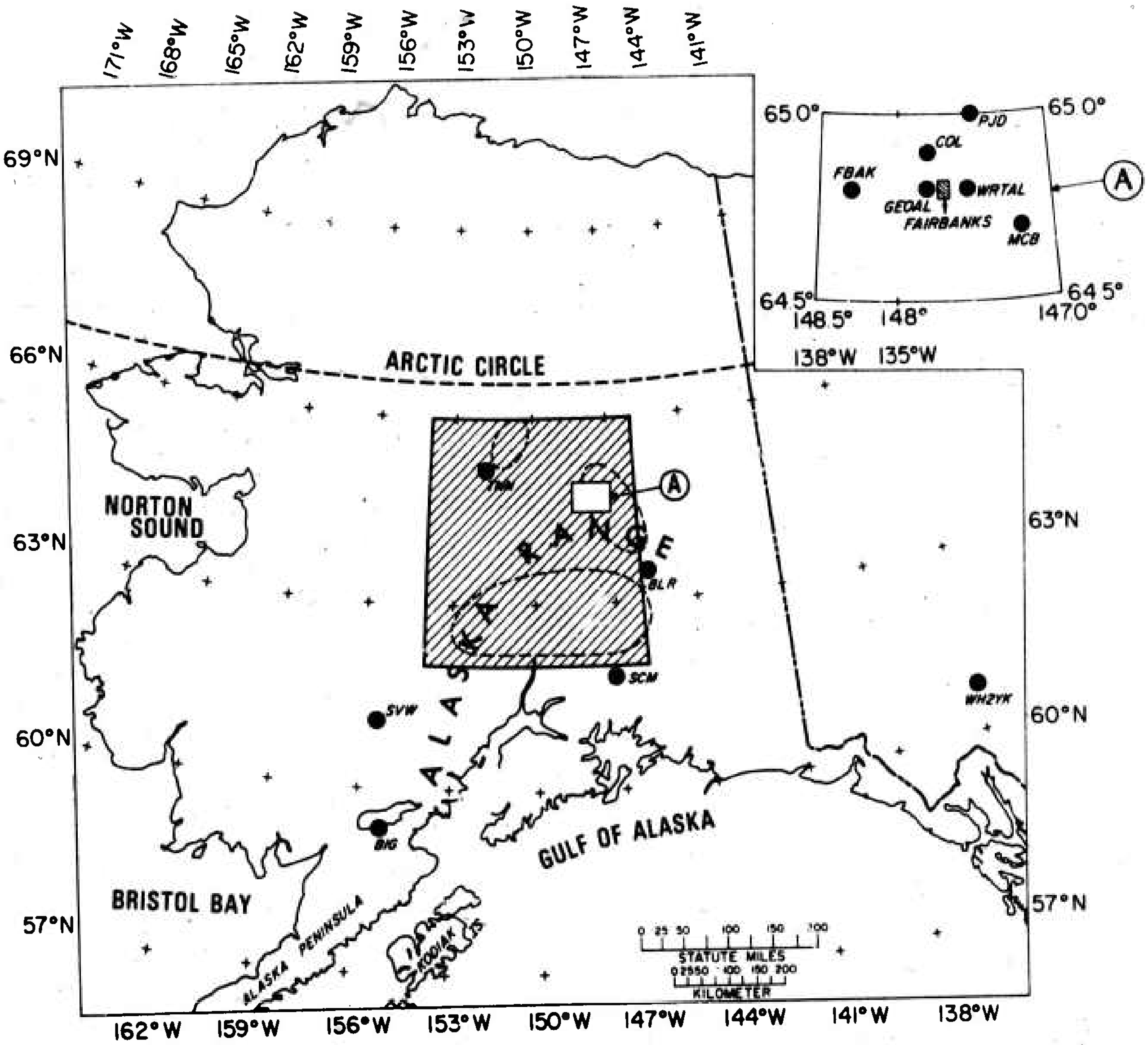

Figure 3. Distribution of local stations.

TABLE VI

Location Results Using a Local Network

			Input σ_o * Sec	Shift Distance (km)	Shift Azimuth o	Output σ_1, ** Sec	TNN	GEOAL	COL	WRTAL	PJD	MCBAL	BLR	WH2YK	SCM	BIG	SVW	FBAK
4	21 Jun 67	Fairbanks	0.868	7.27	9.9	0.538	✓		✓		✓		✓	✓	✓	✓		
6	23 Jun 67	Fairbanks	1.045	7.94	5.9	0.690	✓	✓	✓		✓		✓	✓	✓	✓		
7	08 Sep 68	Fairbanks	1.196	12.47	81.9	0.453	✓				✓		✓	✓	✓		✓	✓
3	06 Feb 67	Fairbanks	3.896	40.90	107.0	0.406	✓		✓		✓			✓	✓	✓		
1	29 Oct 68	Tanana	0.904	8.25	158.6	0.803	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
2	31 Oct 68	Tanana	0.759	2.84	124.7	0.726	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
31	10 Nov 67	Alaska Range	0.929	11.88	135.5	0.482	✓		✓		✓		✓	✓	✓	✓	✓	
32	04 Dec 67	Alaska Range	1.037	14.32	129.0	0.451	✓		✓		✓		✓	✓	✓	✓		
30	11 Oct 67	Alaska Range	0.728	9.15	149.0	0.329	✓		✓		✓		✓	✓	✓	✓	✓	
27	31 Mar 67	Alaska Range	1.090	11.60	99.0	0.423	✓				✓			✓	✓	✓		
33	28 Dec 68	Alaska Range	1.055	13.67	115.5	0.355	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
28	05 May 67	Alaska Range	1.384	16.64	114.6	0.210	✓		✓		✓			✓	✓	✓		

* σ_o = Standard deviation from NOS epicenter and pP depth.

** σ_1 = Standard deviation from least-squares solution.

set is about 13 km from the NOS epicenters. A geographic plot of the location shift vectors is shown in Figure 4. Except for two events in the Fairbanks subregion, the directions of the location shifts from the NOS locations vary between east and southeast. This apparent bias cannot be explained in terms of network instability or distribtuion. The relation between network geometry and location shift is shown in Figure 5 in which the station distances are plotted as logarithmic vectors along their azimuth lines and the location shifts as linear vectors. The results in this figure do not indicate any correlation between the direction of event shift and the distribution of the network used for locating that event. In this regard, however, it was shown in an earlier report (Chiburis and Ahner, 1970) that location bias is a function of the particular network defined for locating, and that, if a constant network is used to locate a set of events, the direction and magnitude of the shifts for all events within an anomaly region are closely similar. It was further shown that, by carefully selecting a network, virtually any bias direction and magnitude one desires could be obtained for the same event set. Although a constant network is not used in the present case, this "network bias" could still be a significant factor for producing the observed southeasterly shifts, because the 12 events were located using networks composed largely of the same stations. In particular, stations PJD, TNN, SCM and WH2YK were used in all 12 of the locations; stations COL, BIG and BLR were used in nine of the locations. If the travel-time anomalies for these stations happen to be large, the similarity among the several networks using them may be enough to explain the observed bias.

In another report (Chiburis and Racine, 1971), it was

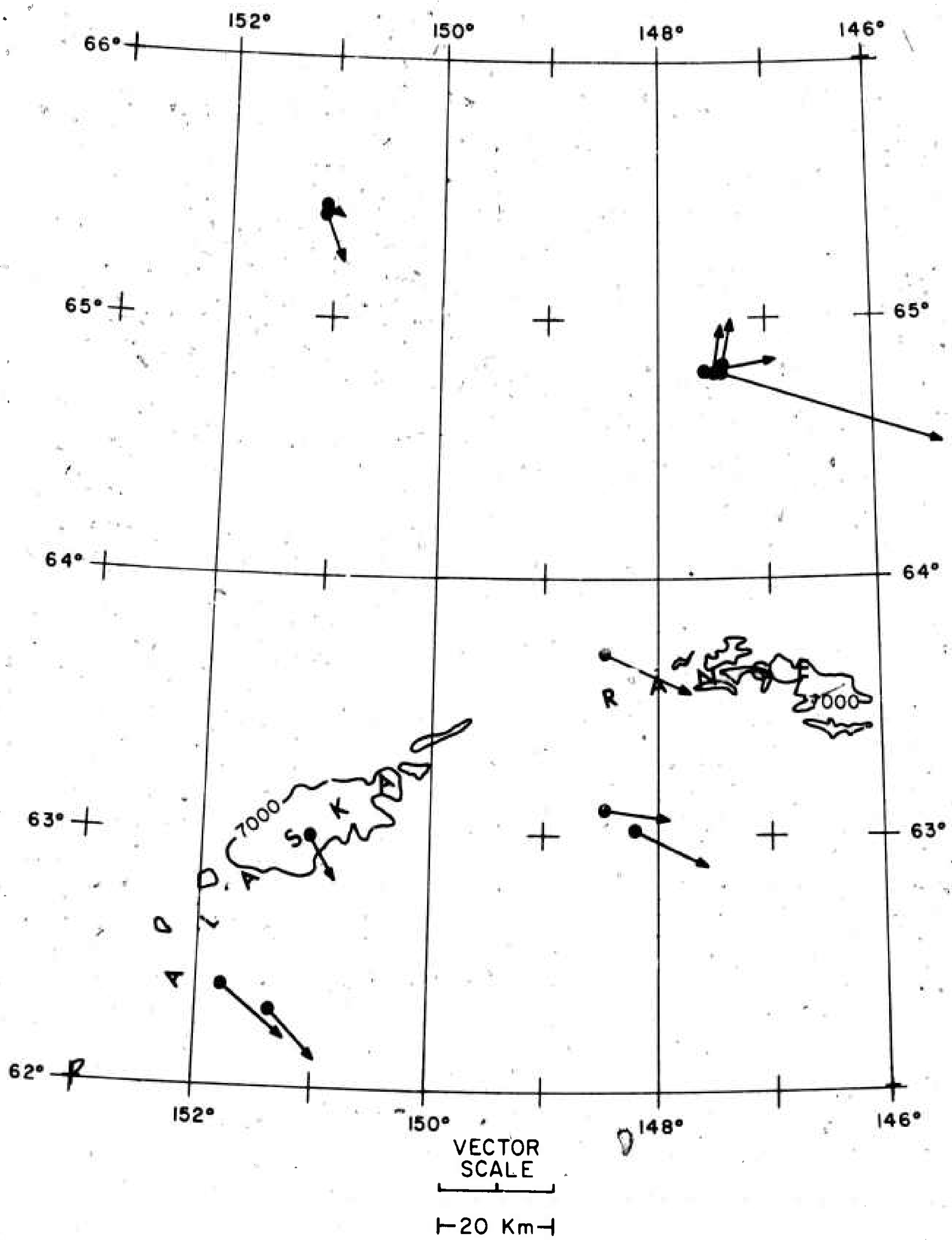

Figure 4. Local network depth restrained locations relative to NOS reported locations.

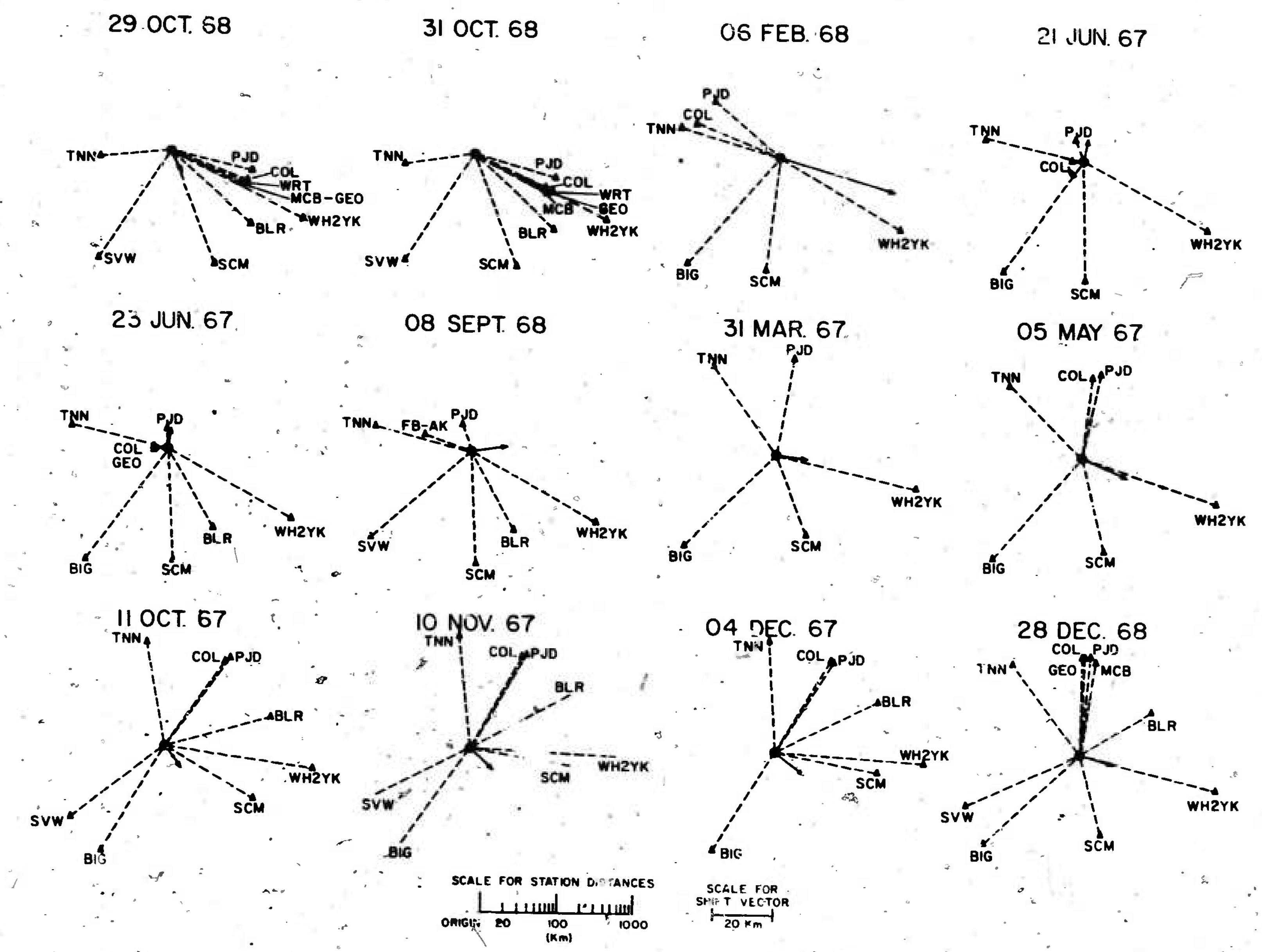

Figure 5. Relationship between network geometry and location shifts.

shown that, although network bias usually predominates, a secondary and sometimes consistent bias can exist almost regardless of the network used, at least for explosions in the Aleutian Islands, and the southeasterly shifts observed on Figures 4 and 5 may possibly be due to this effect. In particular the local network locations may be correct and the NOS epicenters biased to the northwest. This would be consistent with the northward shift of LONG SHOT observed with a teleseismic network, and is the explanation we prefer. An implication would be that the Central Alaskan bias can be traced to the Aleutian underthrusting lithospheric slab. However, the Central Alaskan region is a structurally complex area and the bias may in fact be related to some other structural feature.

It is important at this point to compare the residuals and least-squares time fits obtained from the local network solutions to those obtained from the NOS solutions. Using the NOS hypocenters, a residual at station i for event j can be calculated as

$$R_i^j = T_i^j - T_o^j - H_i^j(\Delta,z)$$

where T_o is the event origin time and the other terms are as defined before. The root-mean-square of the residuals for the total event and local station set is:

$$\sigma_{NOS} = \left\{ \left(\sum_{j=1}^{12} \sum_{i=1}^{N_j} (R_i^j)^2 \right) \Big/ \left[\left(\sum_{j=1}^{12} N_j \right) - 1 \right] \right\}^{1/2}$$

where N_j is the number of local stations recording the jth event. The value of σ_{NOS} is 1.658 sec for these data. Assuming that this figure generally reflects the goodness-of-fit to the travel-time model used (in this case, Herrin (1968)), it can be stated that the fit is poor. However, since many of the stations within the local network shown in Figure 3 were not included in the NOS solution for these events, an "origin-time bias" for each event should be removed from each residual before combining the set; that is

$$R_i^j = T_i^j - T_o^j - H_i^j - \overline{R^j}$$

where $\overline{R^j}$ is the mean of the local-station residuals for the jth event:

$$\overline{R^j} = \sum_{i=1}^{12} \frac{R_i^j}{N}$$

The standard deviation is then calculated as

$$\sigma^{\circ}_{NOS} = \left\{ \left(\sum_{j=1}^{12} \sum_{i=1}^{N_j} (R_i^j)^2 \right) \Big/ \left[\left(\sum_{j=1}^{12} N_j \right) - 1 \right] \right\}^{\frac{1}{2}}$$

The value of σ°_{NOS} is 1.178 sec, a reduction of 0.48 sec compared to the straight root-mean-square. This is still high enough to indicate a poor fit.

If now the standard deviation of residuals is calculated on the basis of solutions obtained using only the local network, the value of σ_{LOC} = 0.511 sec. This result suggests that the

crustal and upper mantle model used for the Herrin (1968) tables is a reasonably good average representation of the crustal and upper mantle structure in Central Alaska; this suggestion is in essential agreement with conclusions drawn by Berg et al. (1967), who concluded that the P-wave velocity in the upper part of the crust in the Fairbanks area is about 5.56 km/sec, which is also near the value of 6.0 km/sec used in the Herrin (1968) model.

To test further the appropriateness of the crustal model, the local network can be used to locate the events with the depth parameter included in the least-squares adjustment. The results of doing this are given in Table VII. The majority of events move only a few kilometers in depth compared to the locations obtained with the depths restrained to a value based on pP. The exceptions to this depth stability are the two Tanana events, which change in depth by 32 km and 25 km upward and in epicenter both by about 30 km northward; the reason for this is that these events are not within the geometric confines of the local network (Figure 3), so the solutions tend to move from the network in the direction of least control. Two other possible exceptions to the depth stability are the events 31 March 1967 and 28 December 1968 in the Alaska Range. The unrestrained solution for 31 March 1967 changes by 31 km upward in depth and 12 km east in epicenter; however, this could be explained by the low number of recording stations which provides only a single degree of freedom in the least-squares procedure. The 28 December 1968 event shifts 18 km upward in depth and 13 km east-southeast in epicenter; it is not entirely clear why this event shifts, as the network is well distributed about the epicenter and the standard

TABLE VII

Restrained and Unrestrained Location Results Using a Local Network

Event	σ_o(sec)	pP Depth Z_1 (km)	σ_1(sec)	Unrestrained Depth Z_2 (km)	dz Z_2-Z_1 (km)	σ_2(sec)	Location Shift (km)	θ	N
21 Jun 67 Fairbanks	0.868	16	0.583	12	-4	0.472	4	018°	7
23 Jun 67 Fairbanks	1.045	16	0.690	11	-5	0.561	5	028°	8
08 Sep 68 Fairbanks	1.196	8	0.453	13	+5	0.368	14	065°	7
06 Feb 67 Fairbanks	3.896	28	0.406	27	-1	0.403	41	108°	6
29 Oct 68 Tanana	0.904	13	0.830	45	+32	0.507	27	002°	10
31 Oct 68 Tanana	0.759	16	0.726	41	+25	0.443	28	001°	10
10 Nov 67 Alaska Range	0.929	93	0.482	90	-3	0.481	12	135°	8
04 Dec 67 Alaska Range	1.037	108	0.451	102	-6	0.445	15	129°	7
11 Oct 67 Alaska Range	0.728	113	0.329	111	-2	0.328	9	149°	8
31 Mar 67 Alaska Range	1.090	82	0.423	51	-31	0.123	12	101°	5
28 Dec 68 Alaska Range	1.055	82	0.355	64	-18	0.267	13	120°	10
05 May 67 Alaska Range	1.384	100	0.210	96	-4	0.189	17	117°	6

σ_o = Standard deviation computed from NOS epicenter and pP depth (Z_1).

σ_1 = Standard deviation computed from restrained (Z_1) solution.

σ_2 = Standard deviation computed from unrestrained (Z_2) solution.

N = Number of stations used in solutions.

deviation for the restrained case (σ_1) is small. Conceivably, this event may actually be shallower than the depth indicated by pP; if pP was mispicked by about 3 sec, the depth would be in the general range of the depth-free solution. This possibility will be further discussed in the next section.

If the 12 restrained hypocenters determined by the local network are now used to compute the anomalies, the results show better consistency at most stations. For example, a comparison of the anomalies computed from the NOS location to those obtained from the local network is given in Table VIII for stations TNN, COL and WH2YK, which are part of the local network, and for stations NP-NT and OXF, which are teleseismic to Central Alaska and recorded a substantial number of the events. The improvement in the consistency of the local stations for the Fairbanks subregion is expected because of the mislocated event 06 February 1967. Because small depth errors are not significant for teleseismic stations, the improvement in anomaly consistency at NP-NT and OXF is less significant than at the local stations. The overall consistency suggests that the event locations within a subregion determined with a local network are more accurate (at least relative to one another) than the reported locations.

One could not reject the hypothesis that all of Central Alaska is one anomaly region from the OXF data. However for NP-NT, (the closest teleseismic station) the Tanana anomalies (from the events with the worst local network control) clearly define a different region. Overall, these data leave open the possibility that all of Central Alaska is a single anomaly region with respect to teleseismic stations farther away than NP-NT. This possibility has, of course, already been suggested by the consistent northwest bias of the NOS location with respect to the local locations.

TABLE VIII

Comparison of NOS and local-network anomalies for Selected Stations

EVENT		TNN		COL		WH2YK		NP-NT		OXF	
No.	Date	NOS	LOC	NOS	LOC	NOS	LOC	NOS	LOC	NOS	LOC
4	21 Jun 67	-4.56	-4.25	-5.55	-4.90	-3.85	-4.44	-2.14	-1.09	-2.49	-2.32
6	23 Jun 67	-3.23	-3.06	-2.70	-3.99	-3.02	-3.93	-3.09	-2.17	-1.40	-1.18
7	08 Sep 68	-2.20	-4.75	--	--	-4.66	-3.41	-2.76	-2.88	--	--
3	06 Feb 67	+1.62	-4.84	-3.18	-5.41	-8.11	-4.81	-1.34	-2.51	-0.88	-1.25
	Average	-2.09	-4.23	-3.81	-4.77	-4.91	-4.18	-2.33	-2.16	-1.59	-1.58
Standard Deviation		2.65	0.82	1.53	0.72	2.24	0.61	0.77	0.77	0.82	0.64
1	29 Oct 68	-0.17	-1.71	-2.44	-2.51	-3.57	-3.50	-5.60	-6.90	-0.90	-1.07
2	31 Oct 68	-1.51	-2.00	-2.83	-2.66	-3.68	-3.56	-6.18	-6.43	-1.47	-1.51
	Average	-0.84	-1.86	-2.64	-2.59	-3.63	-3.53	-5.89	-6.67	-1.19	-1.29
Standard Deviation		0.95	0.21	0.28	0.11	0.08	0.04	0.41	0.33	0.40	0.31
31	10 Nov 67	-0.77	-3.05	-1.35	-2.93	-2.85	-2.22	-1.13	-2.54	-0.89	-1.07
32	04 Dec 67	+0.24	-3.35	-0.22	-2.86	-4.14	-3.25	-0.22	-2.07	-0.69	-0.84
30	11 Oct 67	-0.46	-1.74	-1.11	-1.85	-2.11	-1.79	--	--	-1.03	-1.23
27	31 Mar 67	-1.05	-2.76	--	--	-3.07	-3.10	-1.51	-1.99	--	--
33	28 Dec 68	-1.90	-3.11	-3.41	-3.60	-2.43	-3.12	-2.60	-2.28	--	--
28	05 May 67	-0.70	-3.53	-1.78	-3.17	-3.37	-2.93	-1.70	-2.89	-1.33	-1.51
	Average	-0.77	-2.92	-1.57	-2.28	-3.00	-2.74	-1.43	-2.35	-0.99	-1.16
Standard Deviation		0.70	0.64	1.17	0.65	0.72	0.59	0.87	0.37	0.27	0.28
Overall Average		-1.22	-3.18	-2.46	-3.39	-3.99	-3.34	-2.57	-3.07	-1.23	-1.33
Standard Deviation		1.63	1.06	1.48	1.10	1.67	0.84	1.84	1.85	0.54	0.43

TELESEISMIC LOCATIONS USING CALIBRATION EVENTS

If a calibration event is selected from each of the three subregions in Central Alaska and anomalies at both local and teleseismic stations are computed from the restrained hypocenters determined in the previous section, and if the anomalies are used as corrections, the events in the respective subregions can be located relative to the calibration events. In this way, anomaly stability can readily be evaluated as a function of distance between subregions and, to a lesser extent, as a function of depth.

The events selected for calibration purposes are 21 June 1967 Fairbanks (to locate 06 February 1967, 23 June 1967 and 08 September 1968); 29 October 1968 Tanana (to locate 31 October 1968; and 10 November 1967 Alaska Range (to locate 04 December 1967, 11 October 1967, 31 March 1967, 28 December 1968 and 05 May 1967). The location results of subregion calibration using confined local and teleseismic stations are given in Table IX for both restrained and unrestrained solutions. In the Fairbanks subregion, the three events shift about 5 km in random directions and the standard deviations of solution (σ_r) reduce to about 0.7 sec, less than half the standard deviations obtained without anomalies (σ_o). The depths do not change significantly when the solutions are run depth free. In the Tanana subregion, the single event shifts about 7 km and the depth changes by 2 km. Significantly, the standard deviation is now reduced to about 0.5 sec. When compared to the standard deviation of 1.380 sec from the restrained hypocenter determined by the local network (σ_o), it is clear that the anomalies from the calibration event in this area are

TABLE IX

Subregion Calibration Results for Central Alaska

Event Name	N	σ_o(sec)	Restrained Shift km	Restrained Shift Az	Restrained σ_r(sec)	Unrestrained Shift km	Unrestrained Shift Az	Unrestrained dz (km)	Unrestrained σ_f(sec)
Fairbanks									
21 Jun 67*	58	1.641	--	--	--	--	--	--	--
06 Feb 67	27	1.968	5.2	245°	0.752	5.0	239°	-1	0.752
23 Jun 67	28	1.279	5.4	074°	0.629	4.5	062°	+2	0.624
08 Sep 68	22	2.055	7.2	325°	0.891	3.5	335°	-8	0.820
Tanana									
29 Oct 68*	60	1.349	--	--	--	--	--	--	--
31 Oct 68	33	1.380	7.3	174°	0.502	6.8	172°	-2	0.499
Alaska Range									
10 Nov 67*	51	1.303	--	--	--	--	--	--	--
04 Dec 67	37	1.441	0.2	039°	0.333	0.4	156°	-1	0.328
11 Oct 67	30	0.824	7.5	131°	0.517	3.2	118°	+9	0.274
31 Mar 67	12	1.100	3.5	142°	0.585	3.0	224°	+9	0.398
28 Dec 68	11	1.285	0.1	173°	0.449	1.1	123°	-5	0.369
05 May 67	34	1.525	1.6	215°	0.544	1.6	179°	-2	0.536

* Calibration events.

σ_o Standard deviation from the input location, calculated using only those stations common to the appropriate calibration event.

σ_r Standard deviation from the depth restrained, anomaly solution.

σ_f Standard deviation from the depth free, anomaly solution.

dz Change in depth, from the input value to the depth free solution.

correcting, at least to the first order, the imperfect earth model relevant to the Tanana subregion.

For the Alaska Range subregion, when using the 10 November 1967 event for calibration purposes, the average restrained shift of the five events is only about 2.5 km in a random direction and the standard deviations reduce to below 0.6 sec. When the solutions are allowed to run depth free, the average shift is less than 2 km and the standard deviations are all below 0.4 sec except for 05 May 1967 which is farthest from the calibration event. Since the size of the Alaska Range subregion is about 150 km by 150 km, certainly larger than the 70 km by 25 km accepted in earlier studies (Chiburis and Ahner, 1970), it is expected that the 05 May 1967 event would have the poorest fit. For the unrestrained solutions in the Alaska Range, the depths of the events change only a small amount (less than 5 km), except for two events, 31 March 1967 and 11 October 1967, which both go deeper by 9 km. The standard deviations of these events are reduced from 0.585 to 0.398 sec and 0.517 to 0.274 sec respectively. It may be that the depth-free solutions are yielding more reliable depths for these two events, although it may be that the anomalies are changing slightly across the region. It is impossible to tell if these two events are correctly located in three dimensions, because the standard deviations may reduce only fortuitously when using 10 November 1967 as the calibration event. For example, if the 31 March 1967 event, restrained to a depth of 82 km, is used to calibrate the 11 October 1967 and 28 December 1968 events, the epicenters shift respectively about 1 km and 14 km with depth shifts of 4 km downward and 6 km upward respectively; the standard deviations reduce to 0.268 and 0.019 sec, an almost perfect time fit for the latter. Only further studies will remove

the ambiguity.

If the local stations are removed from the networks and only teleseismic stations are used, the results of locating both with and without anomalies are as given in Table X. In the Fairbanks subregion the shifts are large, but this can be explained by poor teleseismic network distribution. Although the networks have a large aperture if only extreme azimuths are considered (Network Aperture in Table X), the aperture is much less if only one or two stations are excluded. A network of this type is known to give poor locations. For example, the 01 February 1967 event was located with a network having an aperture of 107°; if one station is deleted, the aperture (n-1) reduces to 42° and if two stations are deleted, the aperture (n-2) is 24°.

In the Tanana subregion, the teleseismic network used to locate the 31 October 1968 event is fairly stable down to the (n-2) aperture and the location shift is about 10 km. However, the local network for ~~this~~ event is poor with apertures of 157°, 73° and 55° down to n-2 stations. In the Alaska Range subregion, only two of the events, 04 December 1967 and 05 May 1967 have well-distributed teleseismic networks. The shifts are respectively 3.2 km and 11.1 km; however, as pointed out earlier, the 05 May 1967 event is farthest from the calibration event and is not expected to be as well located. Although the events 11 October 1967 and 31 March 1967 have shifts of about 6 km and 9 km respectively, this may be coincidental because the (n-2) teleseismic apertures are 41° and 20°, hardly large enough to be classed as well-distributed. The 28 December 1968 event has only three stations for locating (no degrees of freedom for a restrained location) and displays the largest shift.

TABLE X

Subregion Calibration Results for Central Alaska Using Only Teleseismic Stations

Event Name	N	Without Anomalies km	Without Anomalies Az	Without Anomalies σ	With Anomalies km	With Anomalies Az	With Anomalies σ	Network Aperture	(N-1) Aperture	(N-2) Aperture
Fairbanks										
21 Jun 67*	51	13.6	276°	1.129	---	---	---	253°	251°	216°
06 Feb 67	21	45.3	288°	0.614	50.0	270°	0.669	106°	042°	042°
23 Jun 67	21	35.2	071°	0.503	45.2	267°	0.577	105°	067°	041°
08 Sep 68	17	63.5	279°	0.411	45.1	271°	0.834	104°	066°	041°
Tanana										
29 Oct 68*	51	20.7	001°	1.098	---	---	---	302°	251°	216°
31 Oct 68	23	55.8	043°	0.676	9.9	133°	0.566	159°	115°	114°
Alaskan Range										
10 Nov 67*	42	28.6	014°	0.739	---	---	---	181°	168°	158°
04 Dec 67	30	39.2	031°	0.555	3.2	074°	0.353	158°	114°	100°
11 Oct 67	22	31.4	349°	0.337	6.5	119°	0.188	181°	044°	041°
31 Mar 67	7	42.1	067°	0.404	9.3	148°	0.359	105°	042°	020°
28 Dec 68	3	69.8	267°	---	68.2	252°	---	093°	---	---
05 May 67	31	24.9	351°	0.956	11.1	251°	0.885	184°	170°	161°

*Calibration event

Therefore, if only well-distributed teleseismic networks are considered, the shifts are about 3, 10, and 11 km and the standard deviations are less than 0.6 sec, except for 05 May 1967 which is 0.885 sec. If we also require a well-distributed local net for the initial location we will discard the 10 km shift of the Tanana event resulting in an average error of 7 km.

When we compare the shifts of these two Alaska Range events obtained without anomalies, the shifts in location reduce from 39 km to 3 km and from 25 km to 11 km. For the Tanana event, the shift reduces from 56 km to 10 km.

Also in Figure 5 we have plotted the shifts resulting when teleseismic anomalies were determined by averaging over the entire suite of Central Alaskan events. We see that on the average the displacement from the local net location is equal to that obtained by a different calibration event in each subregion. In particular the displacements for 04 December 1967 and 05 May 1967 are 12.4 and 7 km respectively for an average of 9.7 km.

Thus, although the reliable results are sparse, a teleseismic location error of 3-11 km, when anomalies are applied, is the expected result, as compared to an average error of 32 km without anomalies for two Alaska Range events and an average error of 40 km if the Tanana event is included.

CONCLUSIONS

From a study of earthquakes occurring in Central Alaska, a Continental region as opposed to an island-arc region or a basin-and-range region, it has been demonstrated that the anomaly technique is valid, especially if the region is divided into subregions according to their anomaly stability.

It was shown that a local network could achieve consistent location solutions as regards standard deviation, or goodness-of-fit, relative to the Herrin (1968) travel-time tables. From these local locations, anomalies could be determined for both local and teleseismic stations and applied to obtain consistent solutions of other events in the subregions.

From the geographic distribution of the events, there are three anomaly subregions in Central Alaska (Tanana, Fairbanks and Alaska Range) between which the anomalies change significantly but within which the anomalies, when applied as corrections, are apparently correcting the inadequate earth model (travel-time table). There is some possibility that some of the separation into teleseismic subregions is forced by poor locations in the Tanana region. The size of the Alaska Range subregion is large, approximately 150 km by 150 km, where five events, calibrated by a sixth, yield consistent locations, both in epicenter and depth.

There are some suggestions i.e., (1) a consistent 13 km southeast bias with respect to NOS epicenters and (2) fair teleseismic locations resulting from averaged anomalies, that the teleseismic anomaly region is even larger than the Alaska Range subregion.

The location errors, obtained by applying sub-region anomalies, are less than 5 km based on nine events when using local and teleseismic stations, and are 3-11 km based on three events when using only teleseismic stations.

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